

Appl. No.: 10/004,060
Amdt. dated September 10, 2004
Reply to Office action of July 13, 2004

Amendments to the Claims:

1. (Currently amended) A production system for processing a workpiece, comprising:

an index system including a plurality of index devices removably mounted on the workpiece at known longitudinally spaced locations therealong, and a longitudinally extending index member releasably engaged with at least two of the index devices such that a position and orientation of the index member are fixed relative to the workpiece by the index devices, the index member having position-indicating features therealong; and

a machine module mounted for longitudinal movement along the index member and operable to perform an operation, the machine module being operable to detect the position-indicating features on the index member and thereby determine a position of the machine module relative to the workpiece,

wherein each of the index devices has a machine-readable sensor mounted therein, the sensor in each index device storing information including an identifier unique to said respective index device, and wherein the machine module includes a reader operable to read the identifier stored in the respective sensor.

2. (Original) The production system of claim 1, wherein the index member has a machine-readable position-indicating strip mounted therealong, and the machine module includes a reader for reading the position-indicating strip so as to determine the position of the machine module relative to the workpiece.

3. (Original) The production system of claim 2, wherein the position-indicating strip comprises an encoder tape.

4. (Cancelled)

5. (Currently amended) The production system of claim 1, wherein each index device comprises a pin structured and arranged to be releasably installed in a hole formed through the workpiece.

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6. (Original) The production system of claim 5, wherein the pin comprises a quick-disconnect pin.

7. (Currently amended) The production system of claim 1, further comprising a controller in communication with the machine module, the controller being programmed with information correlating the identifiers of the index devices with work process information such that the identifier for each index device is associated with a set of work process information pertaining to a zone of the workpiece at which said respective index device is mounted.

8. (Original) The production system of claim 7, wherein the controller is operable to control the machine module to perform at least one work operation on at least one zone of the workpiece based on the work process information stored in the controller for said zone.

9. (Cancelled)

10. (Original) The production system of claim 1, wherein the index member and the machine module include cooperating drive elements for moving the machine module along the index member.

11. (Original) The production system of claim 1, wherein relative movement between the machine module and the workpiece is effected by a drive system independent of the index member.

Claims 12-16 (Cancelled)

17. (Original) The production system of claim 1, wherein the index member includes a first index arm operable to engage one of the index devices and a second index arm operable to engage another of the index devices such that the position of the index member relative to the workpiece is fixed by the index devices.

18. (Original) The production system of claim 17, wherein the first index arm is fixed relative to the index member and the second index arm is adjustable in longitudinal position along the index member.

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19. (Original) The production system of claim 18, wherein each of the index devices has a machine-readable sensor mounted therein, the sensor in each index device storing information including an identifier unique to said respective index device, and wherein each index arm includes a reader operable to read the information stored in the index device engaged by the index arm.

20. (Original) The production system of claim 1, wherein the index system includes an index support system for supporting the index member, the index support system being operable to allow relative movement between the index member and workpiece prior to engaging the index devices installed in the workpiece, the index support system being operable to lock up after the index system engages the index devices so as to immobilize the index member relative to the workpiece.

21. (Cancelled)

22. (Previously Amended) The production system of claim 20, wherein the index support system includes a pair of clamp assemblies operable to apply clamping forces to the workpiece from opposite sides thereof.

Claims 23-25 (Cancelled)

26. (Original) The production system of claim 1, wherein the machine module comprises a drill mounted on a frame that is traversable along the index member.

27. (Original) The production system of claim 26, further comprising an automatic drill changer mounted on the frame and supporting a plurality of drilling tools, the drill changer and drill being cooperative to change a drilling tool held in the drill.

28. (Original) The production system of claim 26, further comprising a fastener insertion device mounted on the frame and operable to insert a fastener into a hole drilled in the workpiece by the drill.

29. (Original) The production system of claim 28, wherein the frame includes a clamp mechanism operable to clamp together parts of the workpiece to be joined by a fastener.

30. (Original) The production system of claim 29, wherein the clamp mechanism is operable to measure a stack-up thickness of the clamped parts through which the fastener must extend to enable selection of a proper length fastener for insertion into the hole in the workpiece.

31. (Original) The production system of claim 30, further comprising a fastener supply system having fasteners of differing lengths and diameters, and a controller connected to the fastener supply system and receiving information from the clamping mechanism as to the stack-up thickness of the clamped parts, the controller controlling the fastener supply system so as to cause the fastener supply system to deliver a proper length and diameter fastener to the fastener insertion device for insertion into the hole in the workpiece.

32. (Original) The production system of claim 31, wherein the fastener insertion device comprises a riveter for inserting a rivet wire into the hole in the workpiece and upsetting the rivet wire to form a rivet joining the clamped parts together.

33. (Original) The production system of claim 32, wherein the fastener supply system comprises a rivet cutter receiving information as to the stack-up thickness of the clamped parts and operable to cut a rivet wire to a proper grip length based on the stack-up thickness and to supply the cut rivet wire to the riveter.

34. (Original) The production system of claim 33, wherein the fastener supply system comprises a plurality of rivet cutters each supplied with rivet wire of a different diameter from the other rivet cutter(s), the controller being operable to select one of the rivet cutters based on a specified rivet diameter for a given location of the workpiece.

35. (Original) The production system of claim 26, wherein the drill is rotatable about at least one rotation axis for varying a drilling direction along which a hole is drilled in the workpiece.

36. (Original) The production system of claim 1, comprising a plurality of index systems each having a different machine module mounted thereon and each being operable to engage and disengage the index devices mounted on the workpiece.

Claims 37-46 (Cancelled)

47. (Original) A production system for processing a workpiece, comprising:
a plurality of index devices removably affixed to the workpiece in known locations thereof, each index device being proximate a different zone of the workpiece, each index device having a machine-readable sensor in which is stored an identifier unique to said respective index device;
a reader operable to read the identifier stored in the sensor of each index device;
a controller connected with the reader for receiving the identifier therefrom, the controller being preprogrammed with process information for each zone of the workpiece, the process information for each zone being correlated with the identifier stored in the sensor of the index device located proximate said zone, and the controller being operable to retrieve the process information for each zone based on the identifier read by the reader.

Claims 48-54 (Cancelled)

55. (Original) A production system for processing a workpiece, comprising:
a plurality of index devices removably affixed to the workpiece in known locations thereof, each index device being proximate a different zone of the workpiece, each index device having a machine-readable sensor in which is stored an identifier unique to said index device;
a reader operable to read the identifier stored in the sensor of each index device;
a controller connected with the reader for receiving the identifier therefrom, the controller being preprogrammed with process information for each zone of the workpiece including information prescribing locations of holes to be drilled in the workpiece, the process information for each zone being correlated with the identifier stored in the sensor of the index

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device located proximate said zone, and the controller being operable to retrieve the process information for each zone based on the identifier read by the reader; and

a drilling device connected with the controller and operable to be controlled by the controller so as to drill holes in the locations prescribed in the process information for each zone of the workpiece.

56. (Original) The production system of claim 55, wherein the drilling device comprises a drilling head mounted in a 2-axis positioning system.

57. (Original) The production system of claim 56, wherein the 2-axis positioning system is operable to releasably engage a pair of the index devices affixed to the workpiece so as to fix a position and orientation of the 2-axis positioning system relative to the workpiece.

Claims 58-64 (Cancelled)

65. (New) A production system for processing a workpiece, comprising:
an index system including a plurality of index devices removably mounted on the workpiece at known longitudinally spaced locations therealong, and a longitudinally extending index member releasably engaged with at least two of the index devices such that a position and orientation of the index member are fixed relative to the workpiece by the index devices, the index member having position-indicating features therealong; and

a machine module mounted for longitudinal movement along the index member and operable to perform an operation, the machine module being operable to detect the position-indicating features on the index member and thereby determine a position of the machine module relative to the workpiece,

wherein the index member includes a first index arm operable to engage one of the index devices and a second index arm operable to engage another of the index devices such that the position of the index member relative to the workpiece is fixed by the index devices, the first index arm being fixed relative to the index member and the second index arm being adjustable in longitudinal position along the index member, each of the index devices having a machine-readable sensor mounted therein, the sensor in each index device storing information

including an identifier unique to said respective index device, and each index arm including a reader operable to read the information stored in the index device engaged by the index arm.

66. (New) The production system of claim 65, wherein the index member and the machine module include cooperating drive elements for moving the machine module along the index member.

67. (New) The production system of claim 65, wherein relative movement between the machine module and the workpiece is effected by a drive system independent of the index member.

68. (New) The production system of claim 65, wherein the index system includes an index support system for supporting the index member, the index support system being operable to allow relative movement between the index member and workpiece prior to engaging the index devices installed in the workpiece, the index support system being operable to lock up after the index system engages the index devices so as to immobilize the index member relative to the workpiece.

69. (New) The production system of claim 65, wherein the machine module comprises a drill mounted on a frame that is traversable along the index member.

70. (New) The production system of claim 69, further comprising an automatic drill changer mounted on the frame and supporting a plurality of drilling tools, the drill changer and drill being cooperative to change a drilling tool held in the drill.

71. (New) The production system of claim 69, further comprising a fastener insertion device mounted on the frame and operable to insert a fastener into a hole drilled in the workpiece by the drill.

72. (New) The production system of claim 71, wherein the frame includes a clamp mechanism operable to clamp together parts of the workpiece to be joined by a fastener.

73. (New) The production system of claim 69, wherein the drill is rotatable about at least one rotation axis for varying a drilling direction along which a hole is drilled in the workpiece.

74. (New) The production system of claim 65, comprising a plurality of index systems each having a different machine module mounted thereon and each being operable to engage and disengage the index devices mounted on the workpiece.

75. (New) A production system for processing a workpiece, comprising:
an index system including a plurality of index devices removably mounted on the workpiece at known longitudinally spaced locations therealong, and a longitudinally extending index member releasably engaged with at least two of the index devices such that a position and orientation of the index member are fixed relative to the workpiece by the index devices, the index member having position-indicating features therealong; and

a machine module mounted for longitudinal movement along the index member and operable to perform an operation, the machine module being operable to detect the position-indicating features on the index member and thereby determine a position of the machine module relative to the workpiece,

wherein the index system includes an index support system for supporting the index member, the index support system including a pair of clamp assemblies operable to apply clamping forces to the workpiece from opposite sides thereof, the index support system being operable to allow relative movement between the index member and workpiece prior to engaging the index devices installed in the workpiece and the index support system being operable to lock up after the index system engages the index devices so as to immobilize the index member relative to the workpiece.

76. (New) The production system of claim 75, wherein the index member has a machine-readable position-indicating strip mounted therealong, and the machine module includes a reader for reading the position-indicating strip so as to determine the position of the machine module relative to the workpiece.

77. (New) The production system of claim 76, wherein the position-indicating strip comprises an encoder tape.

78. (New) The production system of claim 75, wherein the index member and the machine module include cooperating drive elements for moving the machine module along the index member.

79. (New) The production system of claim 75, wherein relative movement between the machine module and the workpiece is effected by a drive system independent of the index member.

80. (New) The production system of claim 75, wherein the index member includes a first index arm operable to engage one of the index devices and a second index arm operable to engage another of the index devices such that the position of the index member relative to the workpiece is fixed by the index devices.

81. (New) The production system of claim 80, wherein the first index arm is fixed relative to the index member and the second index arm is adjustable in longitudinal position along the index member.

82. (New) The production system of claim 75, wherein the index system includes an index support system for supporting the index member, the index support system being operable to allow relative movement between the index member and workpiece prior to engaging the index devices installed in the workpiece, the index support system being operable to lock up after the index system engages the index devices so as to immobilize the index member relative to the workpiece.

83. (New) The production system of claim 75, wherein the machine module comprises a drill mounted on a frame that is traversable along the index member.

84. (New) The production system of claim 83, further comprising an automatic drill changer mounted on the frame and supporting a plurality of drilling tools, the drill changer and drill being cooperative to change a drilling tool held in the drill.

85. (New) The production system of claim 83, further comprising a fastener insertion device mounted on the frame and operable to insert a fastener into a hole drilled in the workpiece by the drill.

86. (New) The production system of claim 85, wherein the frame includes a clamp mechanism operable to clamp together parts of the workpiece to be joined by a fastener.

87. (New) The production system of claim 83, wherein the drill is rotatable about at least one rotation axis for varying a drilling direction along which a hole is drilled in the workpiece.

88. (New) The production system of claim 75, comprising a plurality of index systems each having a different machine module mounted thereon and each being operable to engage and disengage the index devices mounted on the workpiece.

89. (New) A production system for processing a workpiece, comprising:
an index system including a plurality of index devices removably mounted on the workpiece at known longitudinally spaced locations therealong, and a longitudinally extending index member releasably engaged with at least two of the index devices such that a position and orientation of the index member are fixed relative to the workpiece by the index devices, the index member having position-indicating features therealong;

a machine module mounted for longitudinal movement along the index member and operable to perform an operation, the machine module being operable to detect the position-indicating features on the index member and thereby determine a position of the machine module relative to the workpiece, wherein the machine module comprises a drill mounted on a frame that is traversable along the index member; and

a fastener insertion device mounted on the frame and operable to insert a fastener into a hole drilled in the workpiece by the drill,

wherein the frame includes a clamp mechanism operable to clamp together parts of the workpiece to be joined by a fastener, the clamp mechanism being operable to measure a stack-up thickness of the clamped parts through which the fastener must extend to enable selection of a proper length fastener for insertion into the hole in the workpiece.

90. (New) The production system of claim 89, further comprising an automatic drill changer mounted on the frame and supporting a plurality of drilling tools, the drill changer and drill being cooperative to change a drilling tool held in the drill.

91. (New) The production system of claim 89, further comprising a fastener supply system having fasteners of differing lengths and diameters, and a controller connected to the fastener supply system and receiving information from the clamping mechanism as to the stack-up thickness of the clamped parts, the controller controlling the fastener supply system so as to cause the fastener supply system to deliver a proper length and diameter fastener to the fastener insertion device for insertion into the hole in the workpiece.

92. (New) The production system of claim 91, wherein the fastener insertion device comprises a riveter for inserting a rivet wire into the hole in the workpiece and upsetting the rivet wire to form a rivet joining the clamped parts together.

93. (New) The production system of claim 92, wherein the fastener supply system comprises a rivet cutter receiving information as to the stack-up thickness of the clamped parts and operable to cut a rivet wire to a proper grip length based on the stack-up thickness and to supply the cut rivet wire to the riveter.

94. (New) The production system of claim 93, wherein the fastener supply system comprises a plurality of rivet cutters each supplied with rivet wire of a different diameter from the other rivet cutter(s), the controller being operable to select one of the rivet cutters based on a specified rivet diameter for a given location of the workpiece.

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95. (New) The production system of claim 89, wherein the drill is rotatable about at least one rotation axis for varying a drilling direction along which a hole is drilled in the workpiece.

96. (New) The production system of claim 89, comprising a plurality of index systems each having a different machine module mounted thereon and each being operable to engage and disengage the index devices mounted on the workpiece.